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Commonwealth Environmental Water Office

Commonwealth Environmental Water Office

Water Management Plan

Chapter 3.10 – Murrumbidgee River Valley

2020–21



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Please visit: <https://www.environment.gov.au/water/cewo/publications/water-management-plan-2020-21> for links to the main document.

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3.10 Murrumbidgee River Valley

3.10.1 Region overview

(a) *River valley*

The Murrumbidgee River Valley (Figure 1) covers 84 000 square kilometres of southern New South Wales. It is bordered by the Great Dividing Range to the east, the Lachlan River Valley to the north and the River Murray Valley to the south (Green et al. 2011). The river originates in the alpine area of Kosciuszko National Park and flows through the Monaro High Plains and the low-lying plains of the western Riverina, joining the River Murray south of Balranald.

Most of the flow in the Murrumbidgee River comes from the upper portion of the catchment (gaining stream) and is delivered by the main tributary rivers: Cotter, Yass, Molonglo, Queanbeyan, Bredbo, Numeralla, Goodradigbee and Tumut (Kingsford and Thomas 2001). Several tributaries located immediately downstream of the dams contribute significant inflows, including Adelong, Adjungbilly, Gilmore, Hillas, Tarcutta, Kyeamba, Jugiong, Muttama, Billabong and Houlaghans Creeks, and Goobarragandra River (SKM 2011). The middle and lower portions of the catchment do not contribute significant inflows (losing stream).

Regulated water is provided by two major headwater storages, Burrinjuck Dam on the Murrumbidgee River and Blowering Dam on the Tumut River. Collectively these storages have a capacity of 2 654 gigalitres. Blowering Dam and Tantangara Reservoir catchments are also affected by the operation of the Snowy Mountains Hydro Electricity scheme.

(b) *Traditional Owners*

The rivers and wetlands of the Murrumbidgee River Valley hold significant spiritual and cultural importance for Aboriginal people. The Wiradjuri are the largest Aboriginal nation in the Murrumbidgee River valley, with their nation extending from the River Murray in the south to beyond Dubbo in the north, and west to Balranald. At the western end of the catchment are the traditional land of the Barapa Barapa, Muthi Muthi, Nari Nari, Nyeri Nyeri, Wadi Wadi, Wamba Wamba, Weki Weki, and Wolgalu nations. The mountains at the eastern end of the Murrumbidgee River Valley are the country of the Ngunawal and Ngarigo nations. (MDBA 2019).

(c) *Important sites and values*

Supporting a complex range of natural ecosystems, the Murrumbidgee River Valley contains many significant in-channel and wetland habitats which provide important habitat for a range of aquatic and terrestrial species including frogs, fish and waterbirds.

Commonwealth water for the environment is delivered to a number of important regions in the Murrumbidgee River Valley, including but not limited to the mid-Murrumbidgee wetlands, Yanco Creek system, Lowbidgee floodplain and Murrumbidgee River. These regions provide critical habitat for a range of water dependent animals, including internationally listed migratory waterbirds and a range of threatened species including the southern bell frog, Australasian bittern, trout cod, Murray cod, silver perch, native catfish, fishing bat; and freckled and blue-billed ducks.

Murrumbidgee River

The Murrumbidgee River spans approximately 1 600 km (Frazier et al. 2005) and is heavily regulated with 26 dams, weirs and irrigation channels (SKM 2011). The lowland section of River between Gandagai and Balranald consists of meandering channels and wide floodplains, providing a range of aquatic habitats (Green et al. 2011) which play a critical role in the life cycles of a variety of species (MDBA 2012).

River regulation has affected the frequency and duration of floodplain inundation, with the magnitude of small to medium floods on the Murrumbidgee River having significantly reduced (Frazier et al. 1995). This has had a significant impact on the river system and the plants and animals that depend on it. It has also altered the natural seasonal flow patterns, with higher flows now occurring in summer and early autumn to meet irrigation demand and lower flows occurring during winter and spring when inflows are captured in the dam (CSIRO 2008, Frazier et al. 2005). River regulation has significantly contributed to native fish declines in the Murrumbidgee, with the native riverine fish communities remaining in poor condition (Wassens et al. 2020a, Davies et al. 2008), as part of the Sustainable Rivers Audit, found the overall condition and ecosystem health of the Murrumbidgee Valley to be very poor.

Mid-Murrumbidgee Wetlands

The mid-Murrumbidgee wetlands are located on the Murrumbidgee River floodplain between Wagga Wagga and Carrathool and consist of hundreds of lagoons and billabongs (MDBA 2012a), with several listed as nationally significant in the Directory of Important Wetlands of Australia (EA 2001). The mid-Murrumbidgee wetlands are also part of the Natural Drainage System of the Lower Murray River Management Catchment aquatic endangered ecological community listed under the NSW *Fisheries Management Act 1994*.

The mid-Murrumbidgee wetlands system is characterised by river red gum forests with marginal black box woodlands, and open water habitat of permanent to semi-permanent wetlands with aquatic plants such as spike rush, garland lily and spike rush (NSW OEH 2019a, MDBA 2012a, CSIRO 2008). Many of these wetlands rely on higher flows in the Murrumbidgee River to fill (Murray 2008). However, due to river regulation, inundation frequency and duration has significantly reduced, resulting in the overall poor condition of the mid-Murrumbidgee wetlands. Whilst the use of pumping infrastructure to deliver water for the environment has helped to improve or maintain the condition of a small number of wetlands in the mid-Murrumbidgee, it is not as ecologically effective as filling wetlands with a reconnecting river flow. As such, a high priority for environmental watering is reconnecting these wetlands to help the recovery of aquatic vegetation and improve the health of the river by enabling nutrients and animals to flow back to the river.

Murrumbidgee Irrigation Area wetlands

A number of significant wetlands occur in the Murrumbidgee Irrigation Area and require the use of irrigation infrastructure to receive environmental water. This includes Fivebough and Tuckerbil Swamps which are listed as wetlands of international importance under the Ramsar Convention. Both of these wetlands support a high abundance and diversity of waterbirds, including migratory waterbirds listed under international agreements (JAMBA, ROKAMBA, CAMBA, Bonn Convention) and threatened species, including the endangered Australasian bittern and Australian painted snipe (EPBC Act). They also provide significant breeding habitat for waterbirds including egrets and brolgas (White 2011).

Yanco Creek System

The Yanco Creek system consists of four major creeks, the Yanco, Billabong, Colombo and Forest creeks, and receives a majority of inflows from the Murrumbidgee River but also catchment inflows from the unregulated Billabong Creek. The system discharges into the Edward River which is an effluent of the River Murray (Alluvium 2013). This system is known to provide important native fish habitat, including for the threatened trout cod and freshwater (eel-tailed) catfish (Alluvium 2013). Floodplain wetlands occur throughout the Yanco Creek system providing important habitat for a range of species, this includes Wanganella Swamp which is a significant waterbird breeding site located in the Forest Creek system.

Lower Murrumbidgee (Lowbidgee) Floodplain

The Lowbidgee floodplain is located between upstream of Maude and Balranald and is listed on the Directory of Important Wetlands in Australia (EA 2001) and forms part of the Natural Drainage System of the Lower Murray River Catchment aquatic endangered ecological community listed under the *NSW Fisheries Management Act 1994*. The Lowbidgee floodplain contains the third largest river red gum forest in Australia (Murrumbidgee CMA 2009), some of the largest lignum wetlands in New South Wales (CSIRO 2008) and also has significant black box and reed bed communities (Murrumbidgee CMA 2009). Some of the Murray-Darling Basin's largest breeding sites for colonial nesting waterbirds and migratory waterbird species listed under bilateral agreements occur on the Lowbidgee floodplain (Wassens et al. 2019a).

The Lowbidgee floodplain can be inundated through controlled diversions from Maude and Redbank weirs or via overbank flooding from the river. The Lowbidgee floodplain can be divided into three wetland systems based on distinctive hydrological and ecological characteristics and are Gayini Nimmie-Caira, Fiddlers-Uara and Redbank systems. Gayini Nimmie-Caira supports extensive areas of lignum shrubland that provides important waterbird breeding habitat and important habitat for the threatened southern bell frog. Fiddlers-Uara creeks are the most upstream major distributaries on the Lowbidgee and support black box woodlands with lignum, nitre goosefoot and river cooba understory (MDBA 2012b, SKM 2011, NSW OEH 2019a). The Redbank system consists of North and South (Yanga National Park) Redbank and is dominated by river red gum forests and woodlands with marginal black box woodlands (CSIRO 2008), and a high proportion of open water and semi-permanent wetland communities, including aquatic herbs and spike rush sedgeland (MDBA 2012b, NSW OEH 2019a). This area also provides important waterbird breeding habitat.

At the western edge of the Lowbidgee is the Western Lakes, which is a complex of ephemeral lakes, wetlands and connecting waterways. The Western Lakes were disconnected from the Murrumbidgee River in the early 1900's due to the construction diversion structures on the floodplain (Kingsford and Thomas 2001, NSW OEH 2012) and remained isolated until flow diversion works enabled the delivery of water for the environment in 2011 (NSW OEH 2012). This area provides habitat for a diverse range of waterbirds.

Junction Wetlands

The Junction Wetlands lie between Balranald and the confluence of the Murrumbidgee and Murray rivers. This area consists of a number of creeks, lagoons and areas of river red gum forest, black box and mallee (SKM 2011).

(d) Stakeholder engagement

In the Murrumbidgee River Valley, the planning, management and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders include the New South Wales Department of Planning, Industry and Environment (DPIE) – Biodiversity and Conservation, NSW Department of Primary Industries (DPI) - Fisheries, WaterNSW, Nari Nari Tribal Council, scientists from Charles Sturt University engaged in monitoring the outcomes of Commonwealth environmental water use, Murray-Darling Wetlands Working Group, The Nature Conservancy and the Murrumbidgee Environmental Water Advisory Group (EWAG).

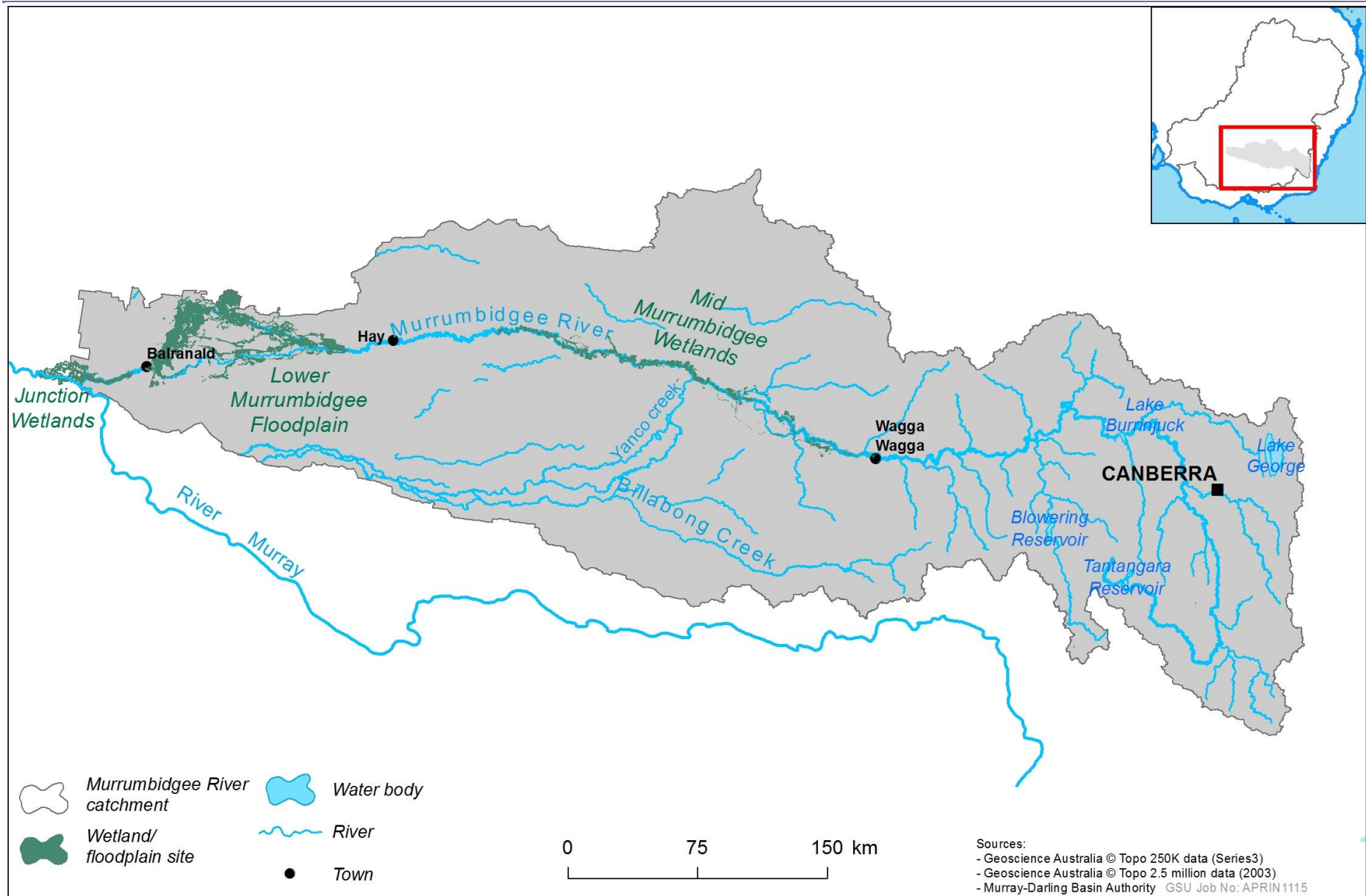


Figure 1: Map of the Murrumbidgee catchment including major towns and headwater storage (courtesy of the Murray-Darling Basin Authority).

3.10.2 Environmental objectives

Objectives for environmental water delivery in the Murrumbidgee River Valley are based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, the Ramsar site ecological character description for Fivebough and Tuckerbil swamps and best available ecological knowledge.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's (CEWO) commitment to adaptive management.

Vegetation: Maintain or improve the condition, and maintain or increase the extent, of native riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Increase waterbird abundance and maintain species diversity by supporting naturally triggered breeding events, and maintaining suitable refuge, feeding and breeding habitat.

Native fish: Prevent loss of native fish species and improve population structure, distribution, and species abundance by supporting opportunities for movement, dispersal, reproduction, and recruitment.

Other vertebrates: Provide habitat to support survival of other native aquatic species, including frogs and turtles; and support opportunities for reproduction and recruitment.

Invertebrates: Provide habitat to support increased microinvertebrate and invertebrate survival, diversity, abundance and condition.

Connectivity: Support longitudinal connectivity, including with the Murray River, and lateral connectivity (within constraints) between the river and floodplain and wetlands.

Processes/water quality/resilience: Support in-stream and floodplain productivity; support nutrient, carbon and sediment transport; provide movement and dispersal opportunities for biota; create quality instream, floodplain and wetland habitat (i.e. including supporting water quality); and maintain or provide a diversity of drought refuge habitat across the landscape.

3.10.3 First Nations Environmental Objectives

Advice on environmental water objectives in the Murrumbidgee catchment has been provided by the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) through the First Nations Environmental Water Guidance project. Table 1 includes just some of the common objectives for the Murrumbidgee catchment selected as they were raised by 2 or more participating Nations for the region. It is important to note these objectives do not represent the detail, depth and complexity of Nations' localised water-related objectives.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Holder is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to articulate objectives for water management.

Table 1: First Nations environmental water objectives for the Murrumbidgee system for 2020-21 (MLDRIN 2020).

<p>Waterways and Places in Need of watering</p> <p>Murrumbidgee, Dry Lake, Yanga Lake, Billabong Creek, Baaka (Darling), Wetlands, Billabongs, Floodplains, Creeks, Other places – parks, forests, islands, Major rivers, Tributaries, Ramsar-listed wetlands.</p>
<p>River Flows and Connectivity</p> <p>Improve water quality, Improve timing and seasonality of flows, Restore flows in degraded rivers, Remove barriers and constraints, Improve flows and quantity (rivers and general), Restore wetland hydrology, Improve river and or floodplain connectivity, Improve tributary flows</p>

Vegetation
Old Man Weed, Cumbungi, Black Box, Lignum, River Red Gum, Grasses
Fish
Murray Cod, Yellowbelly, Catfish, Native fish
Waterbirds
Swan, Pelican, Ducks, Eastern Bittern, Sea eagle ⁱ , Black Swan.
Other species
Turtles, Frogs, Murray Cray, Shrimp, Mussels, Platypus, Yabbies, Water Rat (Rakali), Macroinvertebrates, Emu ⁱ , Kangaroo ⁱ , Birds.

ⁱ Water for the environment targeting other environmental outcomes may influence this species or objective

3.10.4 Recent conditions and seasonal outlook

(a) *Recent conditions and environmental water use*

The Murrumbidgee Valley has experienced dry conditions from early 2017 up until early 2020 when wetter conditions prevailed, contributing to the dry conditions easing (BOM 2020). However, by March 2020 inflows into catchment dams and the Murrumbidgee River had been limited owing to the severity of the dry conditions experienced over the previous three years. Further rainfall in late April 2020 did contribute to an improvement to water resources in Murrumbidgee valley storages, resulting in an increase to general security allocation (NSW DPIE 2020a).

The NSW Department of Planning, Industry and Environment reported in their mid-May 2020 water allocation statement that the Murrumbidgee Valley has averaged 95th percentile conditions in 2019-20, which means only five years out of 100 years of historical record experience drier conditions.

In 2019-20, given the hot, dry conditions and low water resource availability in the Valley, the primary focus of Commonwealth environmental watering was to deliver flows to maintain critical refuge habitats at sites throughout the Murrumbidgee catchment, including:

- Gayini Nimmie-Caira
- North Redbank
- Yanga National Park
- Toogimbie Indigenous Protected Area
- Murrumbidgee Irrigation Area, including Ramsar listed Tuckerbil Swamp
- selected mid-Murrumbidgee and Junction wetlands via pumping.

Delivery of Commonwealth and NSW water for the environment successfully maintained refuge habitat which supported:

- native vegetation communities, including growth of aquatic plant species such as spike rush, spiny mud grass, cumbungi and nardoo
- a high diversity of native fish, including carp gudgeon, Australian smelt, Murray-Darling rainbow fish, flathead gudgeon, golden perch, bony bream and Murray cod
- all three Murrumbidgee turtle species (broad shelled, eastern long-necked and Macquarie River turtles)
- six species of frogs (barking and spotted marsh frogs, Peron's tree frog, plains froglet, inland banjo frog and the threatened southern bell frog)

- a diverse range of waterbirds including threatened species (such as Australasian bittern, blue-billed and freckled ducks) and migratory shorebirds (such as wood sandpiper, sharp-tailed sandpipers, mash sandpiper, curlew sandpiper and long-toed stint) (CSU 2020; Bourke et al. 2019)
- breeding of frogs, including the threatened southern bell frog; and waterbirds, including royal spoonbills, darters, cormorants, white ibis, nankeen night heron and potentially Australasian bitterns (which were heard calling (James Maguire, NSW DPIE, pers. comms 11 March 2020)).

Flows targeting the northern section of Yanga National Park, however, were suspended part way through delivery due to meter failure at the offtake regulator, resulting in less area inundated than planned. Whilst not achieving inundation of all targeted areas in the northern section of the Yanga National Park, inundated areas supported growth of wetland vegetation and provided habitat for native fish, frogs (including tadpoles), turtles and waterbirds (CSU 2020). The meter at the offtake regulator was repaired in early 2020 and therefore is not anticipated to affect planned delivery of water for the environment into Yanga National Park in 2020-21.

A key environmental water objective of the refuge habitat maintenance flow in Gayini Nimmie-Caira through to Tala Lake and associated creek systems in Yanga National Park was to top up Tala Lake and Tala and Talpee creeks, to support golden perch following the successful spawning and recruitment of this species in 2017-18 and 2018-19. These flows provided refuge habitat throughout Gayini-Nimmie Caira, however, due to flow rates through new Gayini-Nimmie-Caira infrastructure works being lower than expected, flows topped up Talpee Creek but did not reach Tala Lake and Creek in Yanga National Park as planned. Top-up flows of Tala Lake and associated deep creek systems will remain a priority for Commonwealth water for the environment in 2020-21. The identification of this restricted flow rate has been taken into consideration during the planning process to mitigate the risk of flows not reaching these sites.

Commonwealth water for the environment was also delivered to specifically target breeding of southern bell frogs at key sites in Gayini-Nimmie Caira, such as Eulimbah Swamp, where populations had declined and were at risk of local extinction. Commonwealth, in conjunction with NSW water for the environment, successfully supported southern bell frog breeding, with tadpoles followed by metamorphs and juveniles having been observed (CSU 2020). The 2019-20 watering, coupled with future watering, will contribute to maintaining these populations in Gayini-Nimmie Caira.

Commonwealth water for the environment was delivered for the first time using pumping infrastructure to Wanganella Swamp in the Yanco Creek System and to Sunshower Lagoon in the mid-Murrumbidgee to prevent loss of aquatic vegetation from the lack of higher natural flows and to provide habitat for water dependent animals. Monitoring at Sunshower Lagoon provided evidence of a significant increase in aquatic vegetation species diversity compared to previous years (CSU 2020; Bruni, J. et al. 2020) and recorded five species of frogs, including the threatened southern bell frog, tadpoles, eastern long-necked turtles and waterbirds (CSU 2020, Bourke et al. 2020). In response to environmental watering at Wanganella Swamp, NSW DPIE staff, Yanco Creek and Tributaries Advisory Council Environmental Manager and local field naturalists reported sighting the re-establishment of aquatic vegetation, including with significant cumbungi and culturally significant nardoo, turtles, frogs and over 25 species of waterbirds including broilga, red-necked avocet (the first observed in the district since 2010), red-kneed dotterel, white-necked heron, freckled duck, sharp-tailed sandpiper and Latham's snipe.

Details of previous Commonwealth environmental use in the Murrumbidgee River Valley are available at: <https://www.environment.gov.au/water/cewo/catchment/murrumbidgee/history>.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook, across the Murrumbidgee River Valley there is a greater than 80 per cent chance of above median rainfall for the periods of June to August and July to September 2020 (BOM 2020). Additionally, the chance of exceeding maximum temperatures over the coming months is variable across the Murrumbidgee River Valley, ranging from high in the eastern end of the valley reducing to low at the western end of the valley (BOM 2020).

While this forecast indicates that the dry conditions are likely to ease, several months of above average rainfall are needed to see a recovery from the current long-term drought.

(c) Water availability

The volume of Commonwealth environmental water carried over in Murrumbidgee River Valley for use in 2020-21 is 62 gigalitres.

Allocations against Commonwealth water entitlements in the Murrumbidgee River Valley are determined by state governments and will vary depending on inflows. On 1 July 2020, the NSW Department of Planning, Industry and Environment (2020b) announced full opening allocations to high security (i.e. 95 per cent allocation) and conveyance entitlements as per the valley's water sharing plan, and 10 per cent allocation to general security entitlements. Based on this, approximately 137 GL of Commonwealth environmental water is available for use in the Murrumbidgee River Valley as at 1 July 2020.

Based on the expected available volume of water held by the Commonwealth and other water holders (including carryover and forecast allocations), as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be low to moderate in 2020–21. High to very high resource scenarios are only possible if conditions become substantially wetter.

(d) Environmental demands

The environmental water demands for assets in the Murrumbidgee River Valley in 2020–21 are represented in Table 2. The capacity to contribute to some of these environmental demands are contingent on a substantial improvement in water availability in the catchment. For example, a low-level mid-Murrumbidgee reconnection is a high priority under all water resource scenarios, however, under a low water resource availability, there would be insufficient environmental water for this action to proceed.

Table 2: Environmental demands, priority for watering in 2020-21 and outlook for coming year in the Murrumbidgee River Valley.

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for all sources of water in the system)*		Watering history (from all sources of water)	2020-21		Implications for future demands Likely urgency of demand in 2021-22 if watering occurred as planned in 2020-2021
	Flow/Volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	
Mid-Murrumbidgee Wetlands† (includes pumping to Toogimbie Indigenous Protected Area) (PU 4, 5, 6, 9 and may also contribute flows in PU 7, 8, 10, 11, 12, 13)	Infrastructure assisted delivery to individual high priority wetland assets targeting provision of refuge habitat and maintenance of wetland vegetation (minimum of 4 GL required under a very low inflow scenario to support critical refuge requirements) (PU 6)	8 in every 10 years – annual (2 years)	Demand met or partially met over the last 5 years	HIGH to CRITICAL To provide refuge habitat for aquatic animals and maintain established aquatic habitat. However overbank connection is preferred	High Potential for water use under Very Low to Moderate inflow scenarios Up to 16 GL (volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 4.5 GL required under a Very Low inflow scenario)	HIGH TO CRITICAL
	Tombullen storage releases to augment flows over 13 GL/day at Darlington Point (PU 6, 7, 8)	7-8 in every 10 years (2 years)	Demand partially met over the last 3 years	HIGH The condition of the mid-Murrumbidgee wetlands is generally poor due to a lack of inundation.	High Potential for water use under Moderate to High inflow scenarios subject to natural flow event triggers Up to 10 GL per event	HIGH
	Minimum of 15.5 GL/day @ Darlington Point for up to 6 days plus a gradual recession targeting low-lying wetland vegetation and aquatic habitat up to 180 GL (multiple PU's)	7-8 in every 10 years (2 years)	Demand met 2 out of the last 5 years, last met 2017-18.	HIGH The condition of the mid-Murrumbidgee wetlands is generally poor due to a lack of inundation.	Up to 150 GL under Moderate to High inflow scenarios planned for autumn/winter 2021 subject to available allocations	HIGH
Murrumbidgee Irrigation (MI) Area Ramsar sites (Fivebough and Tuckerbil wetlands) and includes other important wetlands in MI Area (PU 14)	Fivebough 500 ML to inundate 60% of wetland.	Fivebough: Shallow water 9 in every 10 years.	Fivebough: Required frequency met over the last 6 years	HIGH Required to maintain ecological character under Ramsar	High Potential for water use minimum of 2 GL under a Very Low inflow scenario	HIGH
	Tuckerbil 500 ML to fill	Fill Tuckerbil 4 of every 10 years	Tuckerbil: Required frequency met over last 5 years.		Moderate to High Potential for water use. Up to 4 GL under Low inflow scenario	
Yanco Creek System (PU 12)	Up to 20 GL, targeting up to 1 400 ML/day @ Yanco Creek off-take targeting low-lying wetland vegetation and aquatic habitat and native fish	3 in every 10 years (3 years)	Demand met or partially met in 2 of the last 5 years, however watering required to maintain condition of wetland-floodplain vegetation	MODERATE Watering, required to maintain the good condition of wetland-floodplain vegetation	Low to Moderate Potential for water use Up to 10 GL under Moderate to High inflow scenarios. Supplementary use prioritised if available.	MODERATE, subject to natural cues
Yanco Creek System – Wanganella Swamp (PU13)	Pumping of 1.5 GL to prevent loss of aquatic vegetation species	7-8 in every 10 years (2 years)	Demand met 2 out of the last 5 years	CRITICAL to prevent loss of aquatic vegetation species (cumbungi rhizomes)	High Potential for water use Up to 1.5 GL under Very Low to Moderate inflow scenarios	HIGH
Yanco Creek System – Wanganella Swamp and Forest Creek (PU13)	Up to 6 GL targeting wetland and black box vegetation communities	3 in every 10 years (3 years)	Demand met or partially met in 2 of the last 5 years	MODERATE Watering following natural cues to maintain condition of wetland-floodplain vegetation	Moderate Potential for water use up to 3 GL if natural flow event triggers an opportunity under Moderate to High inflow scenario. Supplementary use prioritised if available.	LOW, subject to natural cues

* Volumes may be limited by current channel constraints. Roberts and Marston (2011), Hardwick and Maguire (2012), Alluvium (2013)

† Note: Difference in filling height (i.e. flows required to fill a wetland) vary among the lagoons that make up the mid-Murrumbidgee wetlands, and so their condition and watering requirements vary accordingly

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for <u>all sources of water</u> in the system)*		Watering history (from all sources of water)	2020-21		Implications for future demands Likely urgency of demand in 2021-22 if watering occurred as planned in 2020-2021
	Flow/Volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	
Lowbidgee - Core refuge and permanent aquatic habitat sites (PU7)	Up to 74 GL targeting critical refuge habitat requirements (minimum of 8.5 GL is required under a Very Low inflow scenario to meet these needs)	Annual	Demand met over the last 5 years	HIGH to CRITICAL Annual watering required for critical habitat requirements	High Potential for critical/permanent habitats. Volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 4.5 GL required under a Very Low inflow scenario increasing to 41 GL under Moderate inflow scenarios	HIGH to CRITICAL
Lowbidgee – Rookery sites (PU7)	Up to 30 GL in the event of naturally triggered colonial waterbird breeding	As required in response to naturally triggered colonial bird breeding event	As required	HIGH to CRITICAL to support successful completion of waterbird breeding events	Low Potential, unless colonial waterbird breeding is naturally triggered under Moderate to Very High inflow scenario	HIGH to CRITICAL
Lowbidgee - North Redbank (PU7)	Up to 40 GL [‡] targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	River red gum forest and spike rush wetlands 1-3 years (3 years)	Met or partially met over the last 5 years	MODERATE Watering following natural cues, to maintain the good condition of wetland-floodplain vegetation	Moderate Potential for wetland inundation Up to 20 GL under Moderate to High inflow scenarios	LOW , subject to natural cues
Lowbidgee - Yanga National Park (PU7)	Up to 50 GL [‡] targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	River red gum forest and spike rush wetlands 1-3 years (3 years)	Met or partially met over the last 5 years	HIGH Watering required to maintain deep creek fish refuges and condition of wetland-floodplain vegetation	High Potential for wetland inundation Up to 25 GL under Moderate to High inflow scenarios	MODERATE , subject to natural cues
Lowbidgee - Gayini Nimmie-Caira (PU7)	Up to 50 GL [§] targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	Refuge habitat annual Lignum dominated wetlands 1 to 5 years, with duration of up to 7 months	Met or partially met over the last 5 years	HIGH Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	High Potential for wetland inundation Up to 25 GL under Moderate to High inflow scenarios	MODERATE , subject to natural cues
Lowbidgee - Fiddlers-Uara (PU7)	Up to 20 GL targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	Black box and lignum wetlands every 3 to 7 years	Met 2 out of the last 6 years	LOW Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	Low Potential for wetland inundation Up to 10 GL under High inflow scenarios	LOW , subject to natural cues

[‡] Cumulative volume - includes volume allocated for this asset under Lowbidgee Core refuge and permanent aquatic habitat

[§] Cumulative volume - includes volume allocated for this asset under Lowbidgee Core refuge and permanent aquatic habitat

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for all sources of water in the system)*		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020-2021
Lowbidgee - Western Lakes (PU7)	Up to 30 GL to maintain open water habitats and floodplain vegetation	Wetland habitats and open water, black box and lignum wetlands every 3 to 7 years	Met or partially met over the last 5 years	MODERATE Watering following natural cues, to maintain open water bodies and good condition of wetland-floodplain vegetation	Moderate Potential Up to 15 GL under Moderate to High inflow scenario	LOW
Lowbidgee full system watering (PU7)	Up to 180 GL** for Basin-wide waterbird habitat and future population recovery. Improve overall condition of the floodplain. Prioritise use of up to 393 GL of Lowbidgee supplementary allocations if made available.	Opportunistic based on natural occurring rain and flow events	Met or partially met over the last 5 year	HIGH Improve the complexity and health of priority waterbird habitat to maintain species richness and aid future population recovery	Low Potential Up to 90 GL under High inflow scenario. Up to 393 GL of Lowbidgee supplementary allocations will be prioritised if made available under High to Very High inflow scenarios.	HIGH
Murrumbidgee River channel, distributaries and anabranches (PU 6, 7, 8, 9, 10, 11, 12, 13)	Contribute up to 10 GL from Tombullen storage to higher river flows (freshes) in spring-summer to support native fish spawning, recruitment, movement and dispersal.	7 in every 10 years	Met 2 out of the last 6 years	MODERATE Watering following natural cues, required to continue recovery of native fish populations.	Moderate Potential Up to 5 GL if natural flow event triggers an opportunity under Moderate to High inflow scenario.	LOW
	Moderate in-channel pulse targeting native fish movement and recruitment, productivity and in-stream vegetation (flows >3 500 ML/day at Balranald) up to 50 GL	7 in every 10 years	Met 2 out of the last 5 years	MODERATE Native fish populations in the lower Murrumbidgee River are in poor condition. Water required for improved fish passage and connectivity, aquatic habitat and riverine productivity	Moderate Potential Up to 25 GL under Moderate to High inflow scenarios	MODERATE
	Distributary and anabranch freshes to restore flow components most impacted by river regulation and support native fish up to 15 GL	7 in every 10 years to annual	Demand met 2 out of the last 5 years	MODERATE Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	Moderate Potential subject to natural cues up to 7.5 GL	MODERATE, subject to natural cues
	Contribute to managing water quality issues within in-stream and wetland environments across the Murrumbidgee Catchment	Contingency in response to poor water quality	As required	CRITICAL Provide refuge habitat for aquatic animals due to poor water quality, including potential hypoxic conditions.	Contingency in response to poor water quality/aquatic habitat availability. This may include up to 15 GL contingency under very low to low inflows, in the absence of IVT (Lower Murrumbidgee weir pool stratification, high risk fish kills).	CRITICAL (Contingency)

** Cumulative volume – includes volumes of all Lowbidgee wetland actions listed above.

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for all sources of water in the system)*		Watering history (from all sources of water)	2020-21		Implications for future demands Likely urgency of demand in 2021-22 if watering occurred as planned in 2020-2021
	Flow/Volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	
Junction Wetlands (PU8)	Flows greater than 5 GL/day @ d/s Balranald Weir and >10 GL/day on the Murray@ Murrumbidgee confluence targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	5 in every 10 years	Demand met in 2 of the last 5 years	HIGH The condition of the Junction Wetland is generally poor due to a lack of inundation	Low Potential under low inflows. Likely to be achieved by other environmental watering actions and also through Lowbidgee Supplementary allocations under Moderate to High inflow scenarios	HIGH
	Flows greater than 7 GL/day @ d/s Balranald Weir targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	5 in every 10 years	Demand met in 1 of the last 5 years	HIGH The condition of the Junction Wetland is generally poor due to a lack of inundation	Low Potential under low inflows. Likely to be achieved by other environmental watering actions and also through Lowbidgee Supplementary allocations under Moderate to High inflow scenarios	HIGH
	Pumping to individual high priority wetland assets targeting wetland vegetation and refuge habitat for native fish, frogs, turtles and waterbirds	7-8 in every 10 years (2 years)	Demand met in 4 of the last 5 years	HIGH TO CRITICAL To support continued recovery of wetland vegetation and provide refuge habitat	HIGH Potential for water use up to 4 GL under Very Low to Moderate inflow scenarios (volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 1.5 GL required under a Very Low inflow scenario)	HIGH

Planning Units (PU) 4 – 14. Identified in the Murrumbidgee Long Term Water Plan Part B: Murrumbidgee planning units (draft for exhibition) (NSW OEH 2019b).

- PU4: Murrumbidgee River – Tumut River Junction to Berembled Weir
- PU5: Murrumbidgee River – Berembled Weir to Gogeldrie Weir
- PU6: Murrumbidgee River – Gogeldrie Weir to Maude Weir
- PU7: Lower Murrumbidgee Floodplain
- PU8: Murrumbidgee River – Balranald to Murray
- PU9: Beavers and Old Man’s Creek

- PU10: Upper Yanco Creek
- PU11: Colombo & Billabong Creeks
- PU12: Lower Yanco Creek to Lower Billabong Creek
- PU13: Lower Billabong and Intersecting Streams
- PU14: Murrumbidgee Infrastructure Dependent Floodplain Wetlands

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.10.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Murrumbidgee River Valley in 2020-21 is to maintain, and where possible improve the health and resilience of aquatic ecosystems including to restore ecologically significant flow components impacted by river regulation under wetter scenarios. Specifically, for the mid-Murrumbidgee wetlands the purpose is to maintain and ensure their ecological capacity for recovery and remains a priority under all resource scenarios subject to available allocations.

Planning for water delivery in the Murrumbidgee River Valley considers all water resource availability scenarios from extreme dry to wet, thereby enabling water managers to efficiently and effectively respond to changing conditions. Delivery of water for the environment to many sites and landscapes in the Murrumbidgee River Valley is scalable (i.e. increase the area, volume delivered, and number sites inundated on the floodplain), depending on the volume of water available and catchment conditions. For instance, should climatic conditions and water availability improve there may be opportunities to increase the number of sites inundated on a floodplain, including sites that require substantial volumes of water to fill.

In the Murrumbidgee Valley, the availability of water for the environment forecast at the beginning of 2020-21 will enable water managers to undertake environmental watering actions planned under all dry resource scenarios, including very high priority action identified under a moderate resource scenario. Most of these managed environmental watering actions will initially focus on maintaining key refuge habitats for waterbirds, native fish, frogs, turtles and other water dependent animals and viability of wetland vegetation in the mid-Murrumbidgee, Murrumbidgee Irrigation Area, Lowbidgee, Junction wetlands and Yanco Creek system. This includes delivery of water to Ramsar listed Fivebough and Tuckerbil Wetlands in the Murrumbidgee Irrigation Area to maintain habitat condition to support threatened waterbird species and waterbirds listed under international migratory agreements. Maintaining refuge habitat with water for the environment, particularly in dry conditions, is critical for the survival of waterbirds, native fish, frogs and turtles (Wassens et al. 2019b). These actions also aim to maintain and prevent loss of threatened southern bell frog populations by supporting breeding and recruitment of these short-lived species.

Other important wetland habitats on the Lowbidgee floodplain, such as the southern section of North Redbank, Paika Lake (Western Lakes) and Kia Lake and Swamp (Gayini Nimmie-Caira) which have not received water for the environment since a managed reconnection in 2017 or large scale natural flooding in 2016, are also targeted to maintain or improve the ecological condition of native vegetation communities, and provide habitat for water dependent animals.

The volume of environmental water expected to be available for use in early 2020-21 will also enable water managers to undertake a full system watering of the northern section of South Yanga (moderate resource scenario action). The primary objective of this action is to top-up Tala Creek and Lake to maintain refuge for golden perch and other native fish, including those recruited on the floodplain in 2017-18 and 2018-19 (Kopf et al. 2019; Bourke et al. 2019). It will also maintain or improve the condition of native vegetation communities and provide habitat and recruitment opportunities for water dependent animals.

Under moderate and wet conditions, further larger scale wetland and floodplain inundation including river-floodplain connection will be targeted to restore components of natural flow regime. These flows aim to disperse essential nutrients, plants and animals, and support reproduction and improve condition of native plants, waterbirds, native fish, frogs, turtles and other water dependent animals. These broader scale watering actions will help to improve the condition and resilience of important sites in the Murrumbidgee River Valley. Building resilience into the system to help sites to maintain condition and function in dry years, and to help cope with climate change. The scale of watering will be informed by prevailing climatic conditions and subject to water availability. River-floodplain connectivity in the lower Murrumbidgee may also be supported by in-channel flows targeting native fish movement and recruitment and in-channel productivity.

Note that under wet conditions, unregulated flows are likely to meet many of the Murrumbidgee River Valley's environmental demands. However, water for the environment may be used to extend the duration of unregulated flows or undertake follow-up watering to achieve environmental watering objectives, subject to constraints and third-party impacts.

If a decline in water quality of in-stream or wetland environments across the Murrumbidgee catchment occurs due to low inflows and dry conditions, or very wet conditions, water for the environment will target protecting refuge habitat for aquatic animals, including for native fish, subject to available allocations.

A key priority for Commonwealth environmental water remains a managed low-level mid-Murrumbidgee wetlands reconnection action, which is generally in poor condition due to lack of repeated inundation. Ideally, a low-level wetlands reconnection with the Murrumbidgee River is required annually to enable the recovery of wetland vegetation. Low-level wetlands were last inundated by the Murrumbidgee River through a managed reconnection in winter 2017. Based on the forecast water resource availability for 2020-21 there is insufficient environmental water holdings for this action to proceed in winter 2020. Should conditions become wetter and environmental water availability improve throughout 2020-21, a managed low-level reconnection may be possible in autumn-winter 2021 (if this priority is not met, by natural, unregulated flows). The aim is to contribute to river flows and inundation of fringing wetlands to continue improvement and promote recovery of wetland vegetation communities, as well as maintain habitat and provide movement opportunities for waterbirds and native aquatic species (including fish, turtles, frogs and invertebrates). The action is subject to water availability, dam release capacities and assessment of potential third-party impacts. The watering action would also contribute to downstream demands, including Yanco Creek, the Lowbidgee floodplain including the Junction Wetlands and potentially the lower Murray. The refinement of arrangements to provide for return flows of environmental water from the Murrumbidgee to the Murray (a “pre-requisite policy measure” in place from 1 July 2019 under the Basin Plan) will enable Commonwealth environmental water used in the Murrumbidgee River to be credited for further environmental use downstream in the River Murray.

Should a managed reconnection not be able to proceed or if mid-Murrumbidgee wetlands are inundated by unregulated flows during 2020-21, maximising carryover volume into 2021-22 is likely to be targeted for a potential managed low-level mid-Murrumbidgee reconnection action in 2021-22.

Additional environmental demands may also be identified during the water year as new information becomes available. Note, under certain levels of water availability, watering actions may not be pursued for a variety of reasons. For example, this may be due to the environmental demand being met by unregulated flows or the ability to deliver environmental water may be limited by constraints or infrastructure works and/or risks.

As in previous years, the use of Commonwealth and NSW water for the environment in the Murrumbidgee River Valley will be adaptively managed throughout 2020-21 in response to changing water availability, and environmental conditions and demands.

3.10.6 Monitoring and Lessons learned

(a) *Monitoring*

Operational monitoring is undertaken for all Commonwealth environmental watering actions and involves collecting on-ground data with regard to environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes.

The Monitoring, Evaluation and Research (MER) Program (previously the Long-Term Intervention Monitoring Project 2014-2019) has sites in the mid-Murrumbidgee Wetlands, Lowbidgee Floodplain and Murrumbidgee River as focus areas. It aims to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition over many years.

Details of monitoring activities funded by the CEWO in the Murrumbidgee River Valley can be found at: <https://www.environment.gov.au/water/cewo/catchment/murrumbidgee/monitoring>.

Monitoring information is also provided by state governments and The Living Murray program.

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings and recommendations from short term intervention monitoring projects (Baldwin 2019) and the five year (2014-19) Long-term intervention monitoring (Wassens et al. 2020 a and b, Kopf et al. 2019, Wassens et al. 2019 b and c) in the Murrumbidgee River Valley is summarised in Table 3.

Table 3: Key lessons learned in the Murrumbidgee River Valley

Theme	Lesson learned
Native fish	<ul style="list-style-type: none"> • Spawning and recruitment of native fish species, such as golden perch, can occur from within the floodplain system. Spawning of golden perch on the floodplain can be triggered using environmental flows, as demonstrated by monitoring in 2018. • Floodplain habitats may be critical for golden perch spawning, growth and recruitment, and importantly provide rare refuges of high-quality habitat and productivity during extreme drought conditions. Management decisions to deliver environmental water to inundate and maintain Lowbidgee floodplain habitats during spring and summer are important to maintain viable native fish populations, and to provide food and habitat for resident populations of fish, frogs and a diverse assemblage of waterbirds. • Spawning of golden or silver perch in the Murrumbidgee River does not appear to be translating to recruitment for either of these species. As stocking of silver perch does not occur in the Murrumbidgee and golden perch stocking is thought to contribute to ~14 per cent of the golden perch population the Narrandera zone, it can be assumed that the population is comprised of wild adults that spawned and recruited locally. Poor young of year recruitment response has also been exhibited by Murray cod, with abundance of juveniles being considerably lower in 2018-19 compared with 2014-15 and 2015-16, but similar to those recorded in 2016-17. The drivers of successful recruitment, the key locations which support juveniles and the causes for the recent failures in recruitment remain unknown. • Since monitoring commenced in 2014, there has been little evidence to suggest that managing discrete flow peaks within the monitored reaches of the mid-Murrumbidgee influenced native fish spawning. This might be in part due to the already higher water flows occurring in the mid-Murrumbidgee compared to other parts of the river, with irrigation deliveries creating conditions suitable for spawning throughout the breeding season. • Wetland native fish species diversity was highest in wetlands that have an area of permanent water, including Avalon swamp, Telephone Creek and Waugorah Lagoon.
Frogs	<ul style="list-style-type: none"> • Breeding of many frog species, including the southern bell frog (EPBC Act vulnerable), is triggered by rising water levels in wetlands during October and November. Therefore, watering actions in early spring are important to enhance frog breeding activity and recruitment.

Theme	Lesson learned
	<ul style="list-style-type: none"> • Southern bell frog numbers, particularly in the Lowbidgee wetlands, have increased steadily in response to environmental water actions over the Murrumbidgee Selected Area since monitoring commenced. Nap Nap and Eulimbah swamps are key refuge habitats for the threatened southern bell frog and maintaining these sites is important for the long-term recovery of this species.
Turtles	<ul style="list-style-type: none"> • Maintaining the availability of permanent water holes, particularly at Telephone Creek and Wagourah Lagoon, is important to support high turtle numbers.
Waterbirds	<ul style="list-style-type: none"> • Higher waterbird species richness and abundance has been observed at sites that were inundated by water for the environment in the last five years compared to wetlands that were dry for extended periods. • Where possible, Commonwealth environmental water should be prioritised to provide annual seasonally-inundated habitat (spring-summer) for waterbirds in the Lowbidgee floodplain and mid-Murrumbidgee wetlands. • Most waterbirds commence breeding in spring, however, the stimuli for breeding is usually a combination of season, rainfall and flooding. • When breeding occurs, water levels in active sites need to be maintained into summer months to ensure the successful fledging of young birds. • In the years following large-scale flooding events, provision of environmental water is likely to be extremely important in creating feeding habitat to support survival of young birds. • When there is limited natural overbank flooding, inundating floodplain habitat to create foraging habitat would benefit waterbird populations in the Murray-Darling Basin by promoting the survival of juvenile and adult waterbirds.
Vegetation	<ul style="list-style-type: none"> • Despite the wide range of hydrological regimes and geomorphologies of wetlands in the Murrumbidgee, there is a clear trend that wetlands which have received environmental water more frequently over the past five years support higher species richness of water dependent vegetation species and lower numbers of exotic species. • River red gum encroachment remains a concern in the mid-Murrumbidgee wetlands, particularly at McKennas Lagoon. Given the current level of river red gum at this and other wetlands, mechanical removal coupled with repeat inundation over several years may be required for restoration.
Microinvertebrates	<ul style="list-style-type: none"> • Higher river levels and cooler temperatures in the Narrandera zone may impact the development of a productive and diverse microinvertebrate community. Environmental flows that inundate dried sediments without creating stable high flows or colder water temperature may be important for maintaining high levels of riverine microinvertebrate density. • Watering actions that allow key wetlands to draw down and temporarily dry out will contribute to maintaining microinvertebrate densities.
Processes Connectivity	<ul style="list-style-type: none"> • Rates of metabolism have remained relatively stable over the past five years despite considerable variability in flow volume. There seems to be little capacity for Commonwealth environmental water to have a significant influence on the rates of stream metabolism and nutrient availability via manipulation of water levels in the Murrumbidgee River within existing capacity constraints under normal flow conditions. However, previous work has shown that managed return flows do have the capacity to influence

Theme	Lesson learned
	<p>riverine nutrient availability at local scales, as was the case of the Redbank return flows undertaken in 2014-15.</p> <ul style="list-style-type: none"> • Broad-scale wetland reconnections and periods of low flow are necessary to promote resources for river food webs. Future planning of watering actions that allow for wetland reconnections either via managed return flows or by generating peaks in river height may assist with the mobilisation of carbon and nutrients from the floodplain to the river.
Water Quality	<ul style="list-style-type: none"> • Monitoring of weir pool stratification (the establishment of a thermocline, with warmer, oxygenated water above and cooler, low dissolved oxygen below) and hypoxic water management in the Lower Murrumbidgee River in 2019 showed that high temperatures and low flow conditions have the potential to adversely affect water quality. Mixing of the hypoxic bottom water with oxygenated surface water can result in low dissolved oxygen concentrations throughout the water column thereby potentially causing fish kills. Water quality can be improved and fish kills mitigated against by: <ul style="list-style-type: none"> ○ steadily increasing in-channel flows and gradually releasing hypoxic water from weirs, and ○ exporting hypoxic water from weirs onto the floodplain using existing regulators. • In the absence of Inter Valley Transfers during Summer, target end-of-system flow rates alone (under the Murrumbidgee Water Sharing Plan) are inadequate to maintain acceptable water quality thresholds for aquatic biota under extreme climatic conditions
Hydrology	<ul style="list-style-type: none"> • Water for the environment is the primary driver of ecological responses for water dependent species in the mid and lower Murrumbidgee floodplains. Maintaining core permanent refuge habitats and providing foraging opportunities for resident species should be a priority in all water years. In years of moderate and high water availability, inundation of larger, continuous areas of floodplain habitats that support breeding opportunities should continue to be a priority.
Operational	<ul style="list-style-type: none"> • During the delivery of water for the environment in Gayini Nimmie-Caira in 2019-20, it was identified that a section of the newly constructed water delivery infrastructure was unable to deliver flows at the expected rate modelled. As a result, the duration of flows needs to be extended (due to lower flow rates) to reach and inundate targeted sites downstream of this point. This will be considered when planning future deliveries using this infrastructure. • Removal of carp from a wetland prior to pumping, either through physical removal and/or short-term drying of the wetland, have shown to have positive benefits for frogs and vegetation. It is recommended that this management intervention be implemented when carp numbers increase and declines in vegetation and tadpole diversity become apparent.

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